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(56) Documents cited
GB2232629 A
GB1421602 A
GB0882458 A
US5369869 A
US4268571 A
US4209862 A
US3873654 A
US3286004 A

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Fig.1.

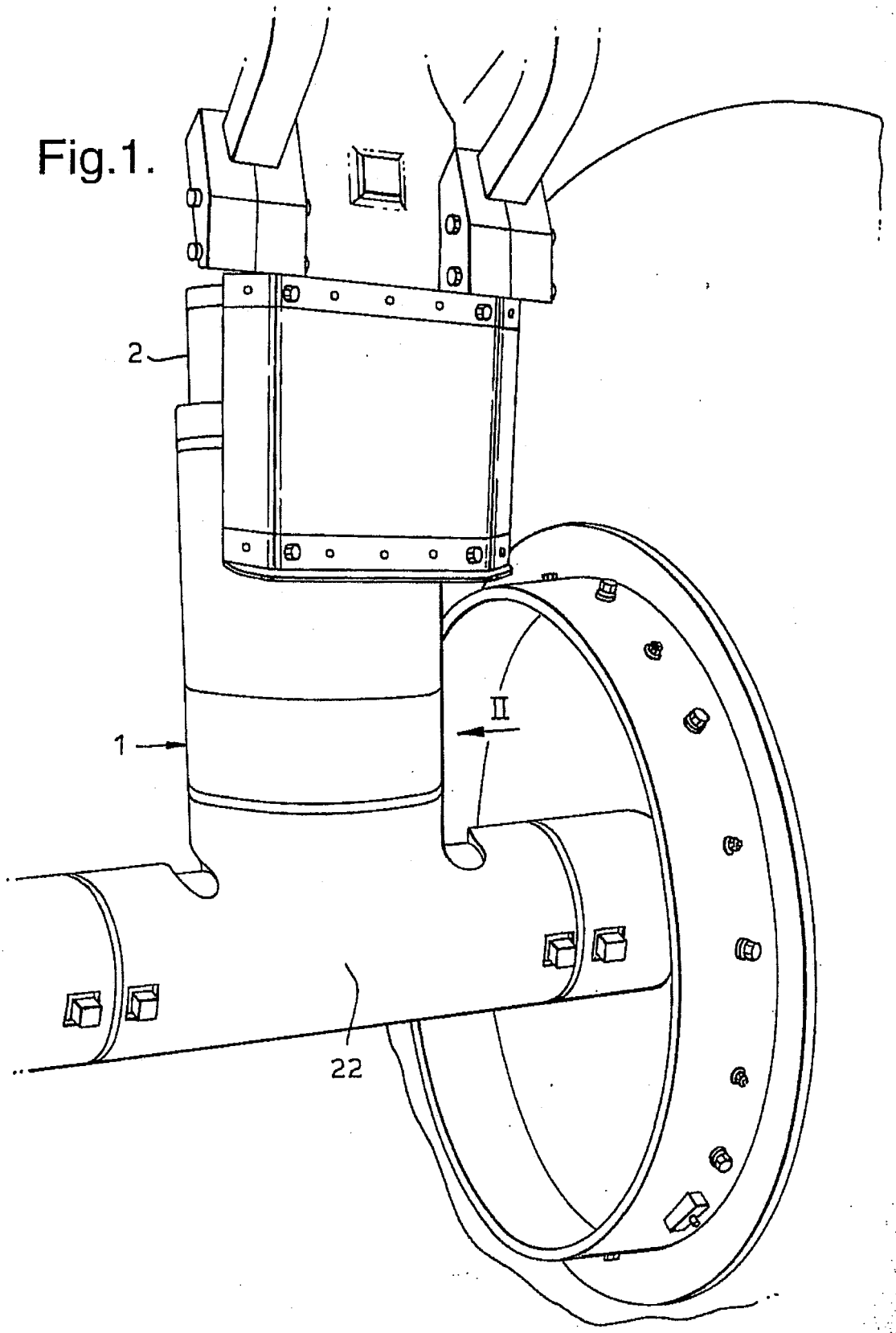

Fig.2.

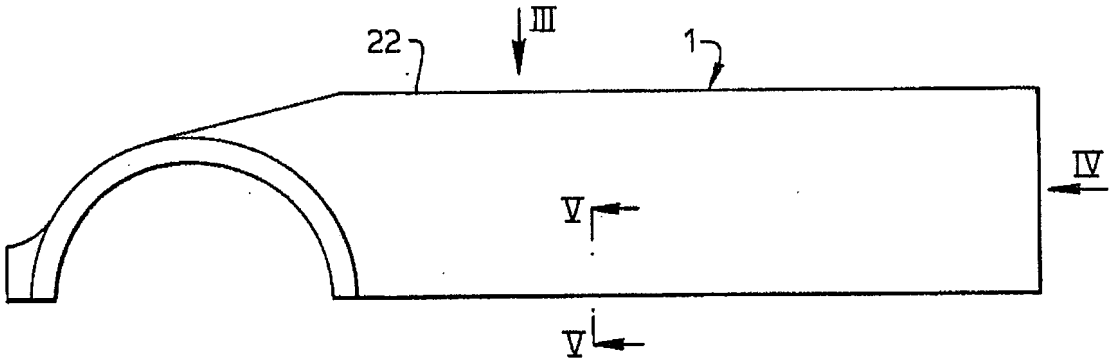

Fig.4.

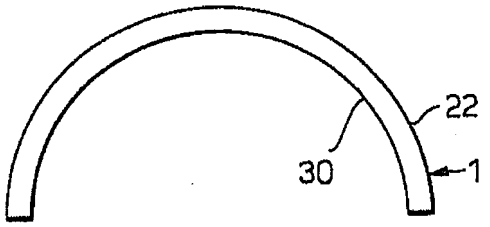

Fig.5.

Fig.6.

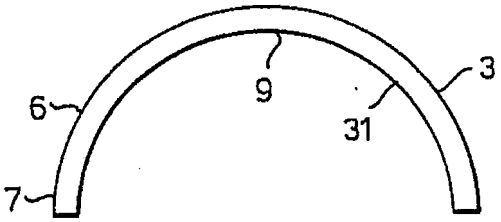

Fig.7.

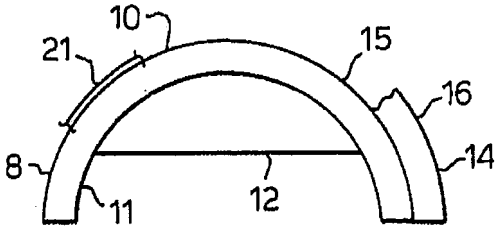

Fig.8.

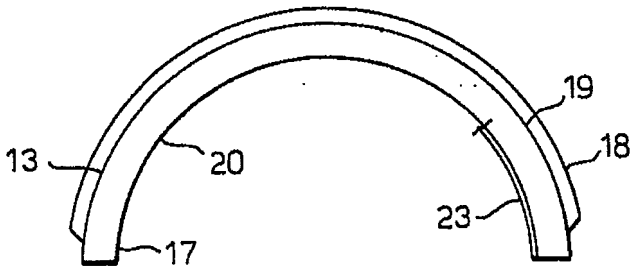

Fig.3.

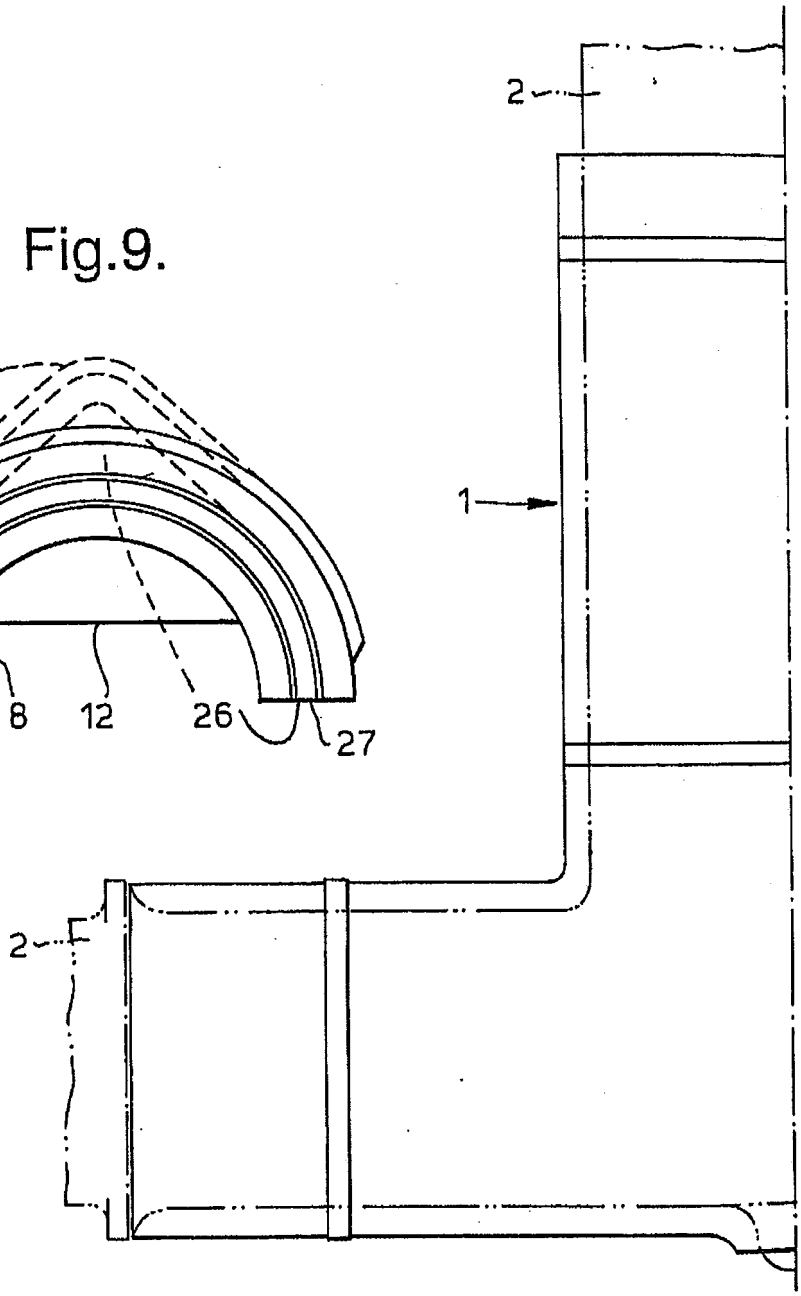

Fig.9.

MANUFACTURE OF COMPOSITE LAMINATES

This invention relates to the manufacture of composite laminates, in particular to an aircraft landing gear strut debris protector.

The aircraft main landing gear oleo struts can be subject to debris attack, particularly during take off and landing. Debris can be in the form of stones, broken concrete and the like and may in some cases be raised from the ground by the nose landing gear, then to be struck by the main landing gear.

It is an object of the invention to provide a debris protector for aircraft landing gear to be attached to the main oleo strut thereof which will avoid impact damage of debris to the gear at the same time as being light in weight and adapted to fit the shape of the gear.

According to one aspect of the present invention there is provided a method of forming an aircraft landing gear strut fairing/debris protector, said landing gear strut having a surface to be protected, said protector comprising first and second fibre reinforced plastics skin elements with a foamed core interposed therebetween, the method including the steps of:

providing a tool having two tool surfaces, each surface comprising a mould for forming a desired skin for said protector, one of said tool surfaces having a surface configuration substantially identical to said surface of said landing gear strut;

forming a lay-up on each said tool surface, each lay-up comprising a fibrous reinforcing material and a plastics matrix material and allowing the matrix material at least partly to harden forming said skin elements;

positioning the tools such that the two skin elements are supported in their desired final relationship to one another; and

introducing a foaming resin between the skin elements to form a connecting foam core therebetween.

According to a second aspect of the invention there is provided a method of forming an aircraft landing gear strut fairing/debris protector comprising first and second fibre reinforced plastics skin elements with a foamed core interposed therebetween, the method including the steps of:

making a mould impression of a portion of said strut to be protected, said mould impression having a surface formed from contact with said strut;

coating said surface with a mould release agent;

forming a first tool lay-up on said surface, said first tool lay-up comprised of fibrous reinforcing material and plastics matrix material and allowing the matrix material to harden;

removing said lay-up from said mould impression and thereby forming a first portion of a mould tool, said first portion having a tool surface identical to said portion of said strut to be protected;

coating said first portion of a mould tool with a mould release agent;

adhering a layer of thickness material to said tool surface, said thickness material having a thickness equal to the desired thickness of the strut fairing/debris protector, and having an external surface identical to the desired external surface of the protector;

coating said thickness material with a mould release agent;

forming a second tool lay-up on said thickness material, said second tool lay-up comprised of fibrous reinforcing material and plastics matrix material and allowing the matrix material to harden;

removing said second tool lay-up from said thickness material and thereby forming a second portion of a mould tool, said second portion having a tool surface identical to said desired exterior surface;

forming a lay-up of fibrous reinforcing material and plastics matrix material on each said tool surface of said first and second portions and allowing the matrix material at least partly to harden;

positioning the first and second portions such that the two surfaces are supported in their desired final relationship to one another; and

introducing a foaming resin between the first and second portions to form a connecting foam core therebetween.

Fibreglass has been found surprisingly effective for use as the fibrous reinforcing material for this application.

The invention will now be described by way of example with reference to the accompanying drawings of which:-

Figure 1 is a front isometric view of a debris protector according to the invention installed on a main oleo strut of an aircraft landing gear,

Figure 2 is a side view of the debris protector of Figure 1 taken in the direction II of Figure 1,

Figure 3 is a view of the debris protector of Figure 2 taken in the direction III thereof, with the protector being truncated at the centre line,

Figure 4 is a view of the debris protector of Figure 2 taken in the direction IV of Figure 2,

Figure 5 is a section along the line V-V of Figure 2,

Figure 6 is an end view of a splash taken from the landing gear of Figure 3,

Figure 7 is an end view of an inner tool taken from the splash of Figure 6,

Figure 8 is an end view of an outer tool taken from the inner tool of Figure 7, and

Figure 9 is an end view of the tools of Figure 7 and Figure 8 used in combination.

Referring to Figures 1 and 3, a debris protector 1 according to the invention for attachment to a main oleo strut 2 of an aircraft landing gear is manufactured as follows. A mould impression or "splash" 3, see Figure 6, is first taken from the strut 2. This is achieved by marking desired boundaries for the debris protector on the strut 2 by attaching foam material (not shown) with adhesive tape to the strut, having first degreased the

strut, and applying release agent to the strut over the area from which the mould impression is to be taken. Two coats of polyester or epoxy resin (polyester preferred) gelcoat are next painted onto the surface. Referring to Figure 6, a layup of fibreglass mat 6 approximately 10mm thick is then applied to the surface and impregnated with polyester resin 7. The resin is then allowed to cure for between four and eighteen hours at a minimum temperature of approximately 21°C. As an alternative to wet lay-up prepreg material may be used. However, the application of heat and some consolidation pressure may be necessary with this method in order to obtain the desired surface finish and structural integrity of the splash.

By the use of gelcoat a smooth surface finish for the splash is achieved from which a tool of substantially identical shape and surface finish to the strut can be achieved.

Next, in order to manufacture a said tool 8 from the splash 3, release agent is applied to the surface 31 of the splash which was formed from the surface of the strut 2, followed by two coats of gelcoat 9. This step is followed by the application to the surface 31 of a fibreglass lay-up 10, see Figure 7, of approximately 12mm

thickness impregnated with polyester resin 11. Optionally some reinforcement 12 to the tool 8 is applied to the rear before cure and cured in position on the tool for strengthening purposes.

Referring to Figures 7 and 8, manufacture of the second tool 13 proceeds as follows. A single sheet of thickness wax, sometimes called lay-up wax 14 is adhered to the tool surface 15 of tool 8. Release agent is optionally applied beforehand. In this case the wax is 12mm thick which corresponds to the total thickness of the debris collector which will be produced in the combined tool. Two coats of gelcoat 16 are next applied either directly or over a release agent to the exposed surface of the thickness wax. When the gelcoat is substantially dry a lay-up 17 for the second tool 13 is placed on the gelcoated surface and impregnated with polyester resin. Further reinforcement 18 is applied to the rear surface 19 of the lay-up and the lay-up is allowed to cure.

Once curing is complete the tools 8 and 13 may be separated from the wax.

In order to manufacture the debris protector, firstly release agents and then lay-ups are applied to the tool surfaces 15 of tool 8 and 20 of tool 13 as follows.

For tool 8, which will form a skin of the debris protector 1 which will be in intimate contact with the main oleo strut 2 in use, a lay-up 21 of two plies of 280 gram fibreglass cloth impregnated with polyester resin is formed on the tool surface 15. To form the skin which will define an exposed surface 22 of the debris collector 3 plies of 280gram cloth are laid up on the tool surface 20 and impregnated with polyester resin, following application of two gelcoats to the tool surface 20. A resulting lay-up 23 is now allowed to cure.

When both lay-ups 21, 23 have cured they may be brought together in a position separated by approximately 8mm as shown in Figure 9. The requisite separation of the lay-ups is achieved by spacing means (not shown) extending between the tools 8 and 13. Appropriate stopoff means (not shown) are next applied to a peripheral region between the two tools 8, 13 and liquid foaming resin 27 is poured into a cavity 26 formed between the two tools 8, 13. The tools are then laid down flat and the polyester expanding foam resin 27 is allowed to foam out to fill the cavity. Once the chemical reaction which causes the foaming is complete, after approximately one hour, foam is trimmed from the edges of the resulting debris protector 1

formed in the tools such that a groove 28 of 6mm depth is formed, see Figure 5, around the periphery of the protector 1. RTV silicone sealant is then applied into the grove to seal the periphery of the protector from any contaminants which the protector may encounter in use.

The surface finish of both surfaces 22, 30 of the debris protector is extremely smooth when manufactured according to the method of the invention and the resulting debris protector possesses sufficient strength in the outer skin 23 to deflect small stones and other objects, whilst the combined structure of the debris protector provides adequate crushability to avoid damage to the strut 2 when the protector 1 is struck by larger debris. In these circumstances the outer skin 23 will progressively collapse and absorb, in combination with the foamed core, sufficient energy from the impact to avoid damage to the strut 2.

In addition, the debris protector 1 is extremely lightweight having regard to its protective qualities and is therefore particularly suitable for use on aircraft.

The snug fit of the inner surface 30 of the protector against the surface of the strut 2 ensures performance of the debris protector according to

specification when installed and reduces the possibility of unwanted vibration of the protector 1 against the strut 2.

The protector 1 may be attached to the strut in any convenient manner, for example by clips or by fasteners passing through the protector itself.

The qualities of fibreglass in the skins 21, 23 have been found to be particularly suitable for the minimisation of impact damage, surprisingly, whereas the use of carbon fibre as reinforcement for the skins was found to be considerably less satisfactory.

CLAIMS

1. A method of forming an aircraft landing gear strut fairing/debris protector, said landing gear strut having a surface to be protected, said protector comprising first and second fibre reinforced plastics skin elements with a foamed core interposed therebetween, the method including the steps of:

providing a tool having two tool surfaces, each surface comprising a mould for forming a desired skin for said protector, one of said tool surfaces having a surface configuration substantially identical to said surface of said landing gear strut;

forming a lay-up on each said tool surface, each lay-up comprising a fibrous reinforcing material and a plastics matrix material and allowing the matrix material at least partly to harden forming said skin elements;

positioning the tools such that the two skin elements are supported in their desired final relationship to one another; and

introducing a foaming resin between the skin elements to form a connecting foam core therebetween.

2. A method of forming an aircraft landing gear strut fairing/debris protector comprising first and second fibre reinforced plastics skin elements with a foamed core interposed therebetween, the method including the steps of:

making a mould impression of a portion of said strut to be protected, said mould impression having a surface formed from contact with said strut;

coating said surface with a mould release agent;

forming a first tool lay-up on said surface, said first tool lay-up comprised of fibrous reinforcing material and plastics matrix material and allowing the matrix material to harden;

removing said lay-up from said mould impression and thereby forming a first portion of a mould tool, said first portion having a tool surface identical to said portion of said strut to be protected;

coating said first portion of a mould tool with a mould release agent;

adhering a layer of thickness material to said tool surface, said thickness material having a thickness equal to the desired thickness of the strut fairing/debris protector, and having an external surface identical to the desired external surface of the protector;

coating said thickness material with a mould release agent;

forming a second tool lay-up on said thickness material, said second tool lay-up comprised of fibrous reinforcing material and plastics matrix material and allowing the matrix material to harden;

removing said second tool lay-up from said thickness material and thereby forming a second portion of a mould

tool, said second portion having a tool surface identical to said desired exterior surface;

forming a lay-up of fibrous reinforcing material and plastics matrix material on each said tool surface of said first and second portions and allowing the matrix material at least partly to harden;

positioning the first and second portions such that the two surfaces are supported in their desired final relationship to one another; and

introducing a foaming resin between the first and second portions to form a connecting foam core therebetween.

3. An aircraft landing gear strut debris protector comprising a composite laminate manufactured according to the method of claim 1 or claim 2.

4. An aircraft landing gear debris protector substantially as herein described with reference to the accompanying drawings.